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SPECIAL REPORT

Space Technology
and Innovation

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PROFILE/22
**MICHAEL
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MISSION DIRECTORATE



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As NASA faces another tough budget year, commercial space advocates are clamoring for a larger role in U.S. deep-space exploration plans. *See story, page 14*

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ViaSat-2's 'First of its Kind' Design Will Enable Broad Geographic Reach

PETER B. de SELDING, PARIS

Satellite broadband services and hardware provider ViaSat Inc. on May 16 announced that its \$625 million ViaSat-2 Ka-band satellite system will use a Boeing-built satellite employing a design that has never been seen before.

In a conference call with investors, ViaSat Chief Executive Mark D. Dankberg said ViaSat-2, to be launched in mid-2016, will not just be a more powerful version of the 140-gigabit-per-second ViaSat-1, which is ViaSat's principal source of consumer satellite broadband revenue.

In addition to a much broader coverage area including the Atlantic Ocean between North America and Europe, and a capacity that ViaSat said will be equivalent to 2.5 times ViaSat-1, the new satellite apparently does away with the classic Ka-band spot-beam design.

"This is not a steerable-beam, spot-beam satellite that offers service anywhere" in its coverage area, Dankberg said. "Ours is an everywhere satellite that offers an orders-of-magnitude improvement" over existing designs. "It's the first of its kind in terms of capacity and geographic coverage. It's just never been done before."

El Segundo, Calif.-based Boeing Space & Intelligence Systems will be using its 702HP as the ViaSat-2 satellite platform. Boeing will also be partnering with Carlsbad, Calif.-based ViaSat in selling ViaSat-2 look-alikes to other markets, using both Boeing-proprietary and ViaSat-proprietary technology, Dankberg said.

While declining to give details of the satellite's on-board power, beam configuration and other specifics, Dankberg did provide several details of the ViaSat-2 system during the conference call. Among them:

■ ViaSat-2 system costs — including the satellite, its launch, launch insurance and a dedicated ground infrastructure — will be 25 percent more than ViaSat-1, or about \$625 million.

Most of the additional cost will



▲ ViaSat said ViaSat-2 will cover seven times the area of ViaSat-1, including the Atlantic Ocean between North America and Europe, and its capacity will be equivalent to 2.5 times that of ViaSat-1.

be in the Boeing satellite procurement. The launch cost is expected to be similar to ViaSat-1, as ViaSat-2 will not weigh much more than the 6,740-kilogram ViaSat-1. Insurance costs have not increased, although the premium ViaSat will pay will depend in part on the total dollar amount it seeks in insurance, and the amount of untested technology on the satellite. The satellite itself will cost about 40 percent more than ViaSat-1, Dankberg said.

■ ViaSat-2 will cover all of North America, Central America and the Caribbean, with coverage including the U.S. East Coast seaboard commercial air routes and the main air and maritime routes between North America and Europe. The coverage area is seven times the size of ViaSat-1's coverage.

■ Because of its radically different design, ViaSat-2's throughput is not easily measured in gigabits per second. Dankberg said that it would offer 2.5 times the capacity of ViaSat-1 in the sense that it can serve 2.5 million customers at today's ViaSat Exede 12 service level, or the same 1 million customers that ViaSat-1 can support at 2.5 times the bandwidth.

ViaSat's high-end Exede 12 commercial service offers customers a 12-megabit-per-second downlink, a 3-megabit uplink and a metered

usage ceiling between 5 a.m. and midnight of 12, 15 or 25 gigabytes per month for \$49.99, \$79.99 and \$129.99 in monthly subscription costs, respectively.

Neither ViaSat nor Boeing released detailed artists' conceptions of ViaSat-2, a measure of ViaSat's opinion of the satellite's novelty. It is also perhaps a consequence of ViaSat's ongoing patent infringement lawsuit against the builder of ViaSat-1, Space Systems/Loral of Palo Alto, Calif.

In the conference call, Dankberg evoked the Loral lawsuit on several occasions. Space Systems/Loral and its former parent company, Loral Space and Communications of New York, have countersued, alleging patent infringement violations by ViaSat. ViaSat is seeking an injunction against further alleged patent infringements, although it remains unclear how this threat will affect Space Systems/Loral's commercial activities.

Space Systems/Loral, which since the ViaSat lawsuit has been sold to MDA Corp. of Canada, has sold other high-throughput Ka-band broadband satellites, most recently a 160-plus gigabit-per-second Jupiter 2/EchoStar 19 consumer Ka-band broadband satellite to ViaSat rival

SEE VIASAT-2 PAGE 4

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NEWS BRIEFS

DoD Renews Controversial Satellite Lease Arrangement

Citing a new process that elevates decisions on certain commercial satellite leases to senior levels, the U.S. Department of Defense (DoD) has renewed a controversial bandwidth leasing arrangement involving a Hong Kong company with substantial Chinese government ownership.

The satellite in question is Apstar 7, operated by APT Satellite Holdings. The company is nearly 40 percent owned by China Aerospace Corp., which in turn is owned by the Chinese government. The new decision-making process was used to execute the one-year, \$10.7 million contract renewal with Harris CapRock Government Solutions of Fairfax, Va., which provides DoD with satellite solutions using capacity leased from third parties, according to a DoD statement.

"The Department of Defense has initiated an oversight mechanism to better manage and assess leasing commercial communication services provided over satellites owned, operated, or launched from states currently subject to comprehensive or tailored economic sanctions. This oversight mechanism will more thoroughly scrutinize potential satellite communication leases and potential alternatives with the main purpose of protecting national security interests, even while providing operational capability," the DoD statement said.

Approval for such leases will now be made at the joint staff-DoD chief information officer level, the statement said. Previously, such decisions were made within the Defense Information Systems Agency.

The Pentagon originally entered into the Apstar 7 lease in May 2012 to fulfill a requirement for single-satellite coverage of all of Africa from U.S. Africa Command. The Pentagon said Harris CapRock, through APT Satellite Holdings, was alone among its 18 approved satellite telecom solutions providers in being able to fulfill that need.

Nevertheless, the lease has drawn criticism from some lawmakers including Rep. Mike Rogers (R-Ala.), chairman of the House Armed Services strategic forces subcommittee, who objected to relying on China, which is widely viewed as a potential adversary, for satellite services.

"Under close examination, APSTAR-7 remained the only satellite solution available that meets U.S. Africa Command's SATCOM requirements, and operational necessity dictated that the lease be renewed," the DoD statement said. "Simultaneously, we are actively working to identify future options to support AFRICOM's need to assure that DoD can move to a more preferred solution in the future."

The statement also reaffirmed DoD's commitment to work with industry to find better ways to meet its space-related needs.

Harris CapRock, in a statement, said: "Harris CapRock incorporates leased satellite capacity into solutions designed based on customer requirements, focusing on a number of factors including equipment size, geographic considerations, atmospheric conditions, look angles, and data rates — all of which are balanced to optimize satellite resources. For all the solutions we design, Harris CapRock provides an added layer of anonymity and security by positioning ourselves between our customer and the satellite fleet operators. Satellite operators do not know the end user or purpose of the solution — only that they are providing satellite capacity to a U.S. company."

China Launches Suborbital Rocket

China launched what it characterized as a scientific sounding rocket May 13 on a mission that the U.S. Air Force said followed a trajectory similar to those used in launches of geostationary orbiting satellites.

"We detected a launch on May 13 from within China," Lt. Col. Monica Matoush, a Pentagon spokeswoman, wrote in an email May 16. "The launch appeared to be on a ballistic trajectory nearly to geosynchronous Earth orbit. We tracked several objects during the flight but did not observe the insertion of any objects into orbit and no objects associated with this launch remain in space. Based upon observations, we assess that the objects reentered the atmosphere above the Indian Ocean. We defer any further questions to the government of China."

According to press release from the Chinese Academy of the Sciences' National Space Science Center, the sounding rocket was launched from Xichang Satellite Launch Center and carried payloads for studying the high-energy particles in the upper atmosphere and near-Earth space.

Lockheed Martin Tapped For 2 More GOES Satellites

The U.S. National Oceanic and Atmospheric Administration (NOAA) picked up options with Lockheed Martin Space Systems of Denver to build two more storm-watching geostationary weather satellites, the head of the company's civil space business said here.

The options bring to four the number of spacecraft Lockheed Martin is building under NOAA's Geostationary-orbiting Operational Environmental Satellite (GOES)-R program. At the time the contract was awarded in 2008 — Lockheed Martin beat out incumbent Boeing to win the award — NOAA said its total potential value, including all options, was just over \$1 billion. The figure has since crept up to \$1.375 billion, NOAA spokesman John Leslie wrote in a May 15 email.

Lockheed's GOES-T option is worth \$175.9 million, and the GOES-U option is worth \$139.7 million, Leslie said. The newly ordered GOES-T and GOES-U satellites are scheduled to launch in 2019 and 2024, respectively, according to Lockheed Martin spokesman Gary Napier.

"For us, exercising options in this [budget] environment is really good news," Jim Crocker, vice president and general manager of civil space at Lockheed Martin Space Systems, said May 14.

The first two satellites in the series, GOES-R and GOES-S, are slated to launch in 2015 and 2017, respectively. Both will fly to space on United Launch Alliance Atlas 5 rockets from Cape Canaveral Air Force Station in Florida under a \$446 million contract awarded by NASA in August.

Leslie said exercising Lockheed's two options will "greatly reduce [the] overall cost" of the GOES program.

"Interrupting the production continuity between GOES-R and GOES-S and GOES-T and GOES-U would result in production inefficiencies, supplier discontinuities, parts obsolescence, and difficulties in retaining skilled workforce and/or rehiring issues," Leslie wrote. "By exercising ... options, NOAA will avoid these inefficiencies and meet its



The May 15 SM-3 Block 1B interceptor launch

Successful SM-3 Test To Inform Production Decision

A Raytheon-built Standard Missile (SM)-3 Block 1B interceptor successfully destroyed a separating, short-range target missile May 15 in a test over the Pacific Ocean that the company said will inform an upcoming production decision on the program.

In separate press releases, Raytheon Missile Systems of Tucson, Ariz., and the U.S. Department of Defense said the sea-based interceptor destroyed the separating mock warhead via impact. "Initial indications are that all components performed as designed, officials said, and program officials will assess and evaluate system performance based on telemetry and other data obtained during the test," the Pentagon said.

It was the third consecutive successful intercept of the SM-3 Block 1B and its Lockheed Martin-built Aegis Ballistic Missile Defense 4.0 fire control system, the Pentagon said.

The SM-3 Block 1B, one of two variants of the SM-3 interceptor family still in development — the Block 1A is deployed and operational aboard U.S. Navy ships — failed in a September 2011 test, prompting concern that the program was being put into production prematurely. The U.S.

Government Accountability Office recommended deferring full-rate production of the Block 1B pending completion of a third straight intercept test, and the U.S. Missile Defense Agency concurred with that recommendation.

Raytheon said the test was carried out against a sophisticated target under challenging, wartime conditions, and that the resulting data will be used to support the upcoming production decision on the program. "Today was the third successful test of Raytheon's next-generation SM-3, and it should give us all great assurance in our nation's ability to take on a wide range of ballistic missile threats," Taylor Lawrence, president of Raytheon Missile Systems, said in a prepared statement.

The SM-3 Block 1B used in the test was launched from the U.S.S. Lake Erie and destroyed a target launched from Pacific Missile Range Facility on Kauai, Hawaii. The interceptor maneuvered toward its target based on guidance from the shipboard Aegis system and then released its kinetic kill vehicle, which acquired the "target re-entry vehicle" and destroyed it via collision in space.

observational requirement for on-orbit availability of two operating imagers through 2036."

Leslie said the total cost of the GOES-R program through that date will be about \$10.9 billion.

Included in that is Harris Corp.'s \$939 million contract to develop the GOES-R ground system — a deal that was worth \$736 million when NOAA awarded it to the company in 2009. Harris also has a \$132 million contract to build GOES-R's ground-based antenna system, Leslie said.

U.S. Air Force GPS 2F Launched Atop Atlas 5

The U.S. Air Force successfully launched its fourth GPS 2F satellite from Cape Canaveral Air Force Station, Fla., May 15.

CORRECTIONS

The story "U.S. Air Force Weighs Faster Move from GPS 3 to New Generation" [May 13, page 7] should have said that Lockheed Martin says launching GPS 3 satellites two at a time — as proposed for the ninth satellite and beyond — would save \$50 million per satellite in launch costs.

The Commentary piece "Was Henry Ford II Right on Transmission Demand?" [May 13, page 19] should have said writer Roger Rusch met with Henry Ford II in 1976.

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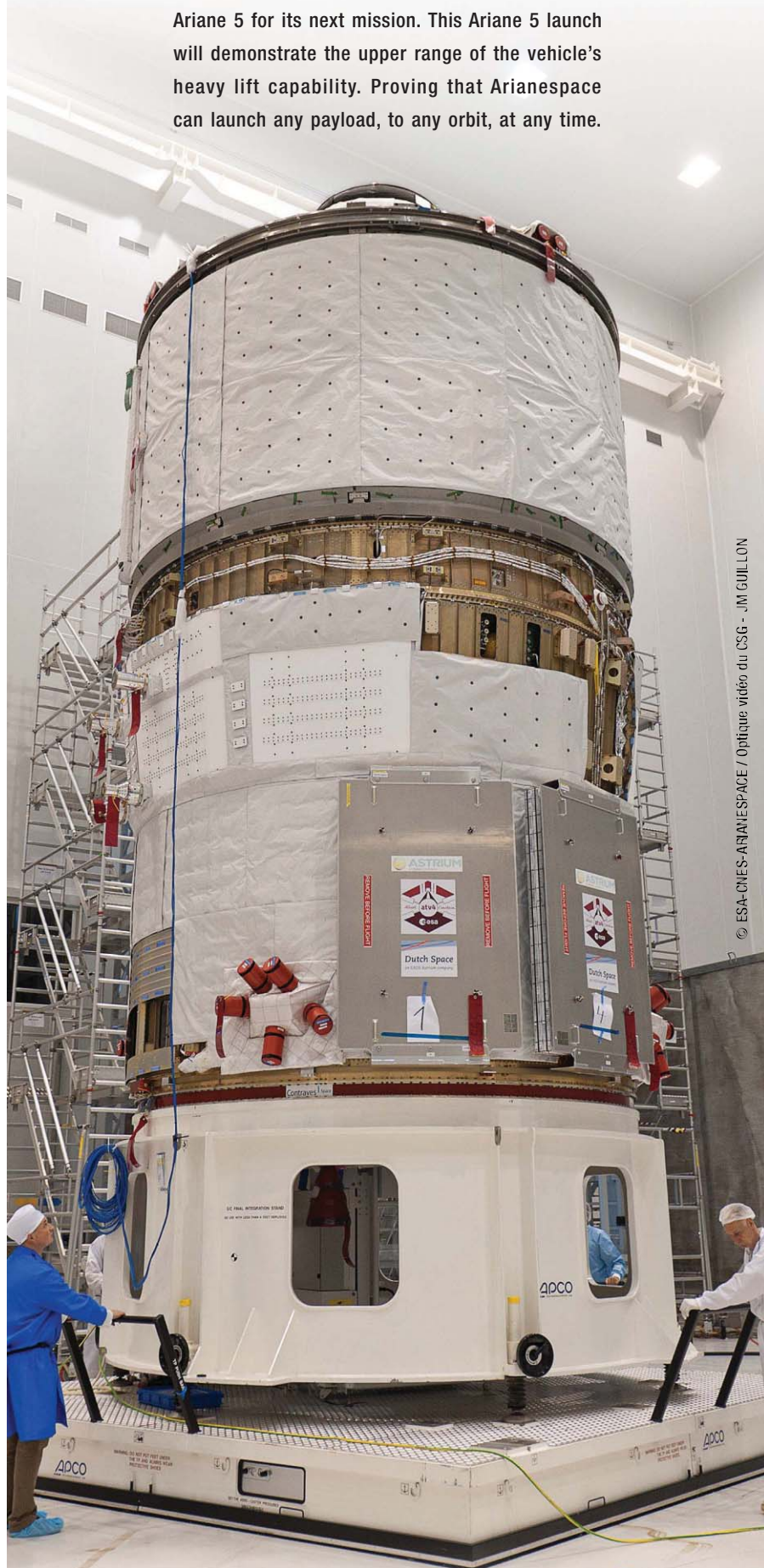
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Preparation

Following on the heels of this month's precise delivery of three small spacecraft aboard the Vega, the 20 metric ton Albert Einstein Automated Transfer Vehicle (ATV) has been installed atop the Ariane 5 for its next mission. This Ariane 5 launch will demonstrate the upper range of the vehicle's heavy lift capability. Proving that Arianespace can launch any payload, to any orbit, at any time.



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DARPA Cancels System F6

WARREN FERSTER, WASHINGTON

The U.S. Defense Advanced Research Projects Agency (DARPA) has canceled a planned formation-flying satellite demonstration in which it has invested more than \$200 million, but a senior agency official said DARPA remains committed to space.

In a May 16 interview, Brad Tousley, director of DARPA's Tactical Technology Office, confirmed the decision to terminate the Future, Fast, Flexible, Fractionated Free-flying Spacecraft United by Information Exchange, or System F6, experiment, which had a notional 2015 launch date.

Tousley cited a number of factors including the lack of an overall integrator to pull the mission together, and said the project's cancellation is in no way a signal that DARPA, the Pentagon's advanced technology development arm, is shying away from space projects.

Other DARPA space projects, including one aimed at developing a low-cost satellite launcher and another to demonstrate satellite salvaging, are proceeding apace, Tousley said. "The [Tactical Technology Office] and DARPA are absolutely committed to space, period," he said.

DARPA is requesting nearly \$233 million for space programs and technology in 2014, compared with just under \$160 million in 2013, according to budget documents posted on the agency's website. The 2014 request includes \$50 million for the System F6 effort, the documents show.

Some industry officials and observers were nonetheless miffed at the decision to cancel a project on which DARPA, according to the budget documents, spent some \$226 million from 2006 through 2012. "The agency was robustly funding this for a number of years," Tousley conceded.

DARPA spent \$40 million on the System F6 program in 2012 and has \$48 million budgeted for 2013, according to the budget documents.

DARPA's mission, generally speaking, is to pursue high-risk, high-payoff technology development projects that could some day benefit the military. These projects are taken on with the understanding that many, if not most, will fail.

"DARPA's role is to take the technical question off the table," Tousley said.

The System F6 experiment was intended to demonstrate and explore the benefits of dispersing the functions of a single satellite across several smaller platforms. The demonstration satellites were supposed to exchange data with one another in space.

The program had a troubled history. DARPA in 2009 awarded Orbital Sciences Corp. of Dulles, Va., a one-year, \$75 million contract to develop the System F6 mission but later terminated that deal. The agency restructured the program, distributing work among several small companies and universities, with none assigned the lead integrator role, Tousley said.

Tousley could not explain the rationale behind the leaderless contracting structure, noting that he only took the helm of DARPA's Tactical Technology Office in January. Upon arriving, Tousley said, he undertook a review of the projects in his portfolio and System F6 did not make the cut.

Tousley also cited a lack of a clear "business case" for heterogeneous, fractionated space missions at the Department of Defense, though he drew a distinction between that and the broader disaggregation concept currently being explored by the U.S. Air Force. Disaggregation entails breaking up the mission sets of large spacecraft and dispersing them among smaller satellites.

Tousley said the System F6 demonstration did not have a traditional mission, such as imaging. "What was going on with the program was really only data transfer — there was nothing else happening," he said.

Software development delays and contractor performance issues also were factors in the decision, Tousley said.

George Davis, president and founder of Emergent Space Systems of Greenbelt, Md., which announced a \$6.7 million software contract on the program in mid-2012, said it is his understanding that the company will be allowed to complete its work. The contract, under which Emergent is developing open-source software that will enable satellite clusters to fly in close enough proximity to

SEE F6 PAGE 10

Viasat-2 FROM PAGE 1

EchoStar/Hughes.

Loral has rejected ViaSat's allegations, saying ViaSat is claiming credit for technology developments that were well understood before ViaSat adopted them.

ViaSat said its Exede consumer broadband service had 512,000 subscribers as of March 31, the end of the company's 2013 fiscal year, which is a 33 percent increase from the same period a year ago.

The cost of securing each new subscriber remains at between \$700 and \$800. ViaSat said churn — the number of subscribers quitting the service — in the three months ending March 31 was nearly 3 percent. Dankberg said many of these were subscribers to ViaSat's former WildBlue service that are upgrading to Exede. He said he expected churn is more like 2.5 percent per month.

As is the case with competitor Hughes' HughesNet Gen4 service, ViaSat's Exede is hunting for customers in areas well served by DSL or other terrestrial broadband, offering what the satellite companies say is faster page-times than most DSL connections.

Dankberg said that as it moves into areas where subscribers have multiple broadband

options, ViaSat will have to accept higher churn rates. It is worth it, he said.

Similarly, Dankberg said, investors should not worry about the high subscriber acquisition costs and the general marketing and research charges associated with improving the Exede service. These and the costs of building Exede consumer equipment will pay off in higher subscriber rates and customers that are happy with the service and unlikely to leave it.

The ViaSat-2 and Exede performance almost overshadowed ViaSat's government business, which reported a 30 percent increase in revenue in the year ending March 31 compared with the previous year, and a 48 percent increase in EBITDA, or earnings before interest, taxes, depreciation and amortization.

Backlog in the government division grew 25 percent.

Demand for mobile broadband services by government, mainly military, customers continues to grow, Dankberg said, and while government mandated budget cutbacks may slow the growth temporarily, he said, the company expected further growth in the current year — "all that in a very tough budget environment," he said.

Europe Readies First Alphasat Telecom Platform for Launch

PETER B. de SELDING,
TOULOUSE, France

Europe's billion-dollar Alphasat I-XL telecommunications satellite, financed by the French and European space agencies to maintain Europe's commercial competitiveness against the likes of Boeing, Space Systems/Loral and Lockheed Martin, is being prepared for a first launch that may be the program's last.

Alphasat I-XL has been purchased by mobile satellite services operator Inmarsat, which will use the satellite to add to its core L-band business. Inmarsat officials attending an Alphasat briefing at Astrium Satellites' facilities here May 17 said Alphasat I-XL offers Inmarsat unsurpassed flexibility of coverage and power, allowing the company to direct power as demand requires among the satellite's 400 spot beams.

London-based Inmarsat will operate Alphasat at 25 degrees east longitude, where the company's Inmarsat 4F2 is currently stationed. Inmarsat Chief Technology Officer Ruy Pinto said that after six months of Alphasat I-XL operations, the Inmarsat 4F2 satellite would be moved to a new slot to broaden Inmarsat's coverage.

When it was first approved by the 20-nation European Space Agency (ESA) and the French space agency, CNES, the Alphasat program, which funded Alphasat I-XL's development, was intended to have Europe's two big satellite prime contractors work together on a satellite design they could use when bidding jointly on big international commercial programs.

It has not quite worked that way. Astrium Satellites and Thales Alenia Space continue to bid together on the occasional program, but they are mainly commercial telecommunications competitors. Neither has won a competition using the Alphasat design, which is too heavy for most commercial satellite projects.

Alphasat I-XL is designed to provide up to 22 kilowatts of on-board power on a satellite whose launch mass could be up to 8,800 kilograms. At one point it appeared the commercial market was moving in that direction, and that Boeing and Space Systems/Loral had products that appealed to it.

To keep Europe in the race, ESA agreed to invest some 438 million euros, which when expressed in today's currency is more than 500 euros, or \$650 million. The French space agency invested a lesser sum on its own. ESA is flying four technology demonstration payloads on Alphasat I-XL, including a laser communications terminal and a new-generation star tracker, that Inmarsat has agreed to operate for at least three years.

Later in the program's development, ESA made Alphasat

into a public-private partnership with Inmarsat. Inmarsat Chief Executive Rupert Pearce said here May 17 that the company has spent \$370 million on Alphasat I-XL, a figure that includes the satellite's construction, insurance and launch aboard a European Ariane 5 heavy-lift rocket.

Inmarsat's financing of the program was helped by a

low-interest European Investment Bank loan of up to 225 million euros, and by financial support from several British regional governments in support of Astrium's British operation.

Alphasat I-XL is currently scheduled for launch in late July from Europe's Guiana Space Center in South America.

But if Alphasat/Alphasat

as an integrated product no longer seems to coincide with the commercial market, several technologies developed for it have found their way into the current commercial satellite platforms of both Astrium Satellites and Thales Alenia Space.

These technologies include a 100-volt power supply regulator that Astrium has inserted into

its Eurostar production line; a plasma-electric propulsion system, called PPS 1350 developed by Snecma of France; and a communications module structure that permits heavier payloads to be supported by a satellite's main structure.

Eric Beranger, chief executive

SEE ALPHASAT PAGE 14



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With Galileo Satellite Shipped for Testing, OHB's Outlook Improves

PETER B. de SELDING, PARIS

Satellite and rocket-hardware manufacturer OHB AG on May 15 said it had shipped the first of its Galileo navigation satellites to a European center for preflight testing, a milestone that could permit two OHB-built Galileo spacecraft to be ready for launch by September.

Bremen, Germany-based OHB, which has emerged as Europe's third satellite system prime contractor after Astrium and Thales Alenia Space, said it is on track to post double-digit revenue and profit increases this year despite a sharp drop in profitability in the first three months of the year.

In a conference call with investors, OHB Chief Financial Officer Kurt Melching said the company had factored in a poor first-quarter profitability when it told investors its revenue would increase by 11 percent this year, surpassing 700 million euros (\$910 million), and that pretax profit would climb 16 percent, to more than 36 million euros.

For the three months ending March 31, OHB reported revenue of 143.6 million euros, up 14 percent from the same period a year ago. But profit before interest and taxes was down 26 percent, to 6.6 million euros.

"What happened in the first quarter is in line with our planning," Melching said. "We expect no difficulties in reaching our [forecast] for the year."

The company's backlog, at 1.56 billion euros on March 31, was up 25 percent from a year ago.

OHB Chief Executive Marco R. Fuchs said during the conference call that the first Galileo FOC — full operational capability — satellite was shipped May 15 to the European Space Agency (ESA) European Space Research and Technology Centre in Noordwijk, Netherlands.

The satellite will undergo multiple examinations at the facility, including thermal vacuum testing, and results will be known by mid-July. If no issues are discovered during testing, OHB will be ready to deliver to ESA the first two satellites in mid-August. The first satellite was completed at OHB nearly a year ago, but software issues slowed the delivery to ESA.

Fuchs said the mere fact of finally shipping the satellite should be seen as a sign of the program's credibility in terms of proceeding to launch this fall. OHB and its partner, Surrey Satellite Technology Ltd. of Britain, are under contract to ESA and the 27-nation European Union's executive commission to build 22 Galileo satellites.

ESA is managing the launch of the satellites. The first spacecraft will be placed two at a time into medium Earth orbit by a Europeanized version of Russia's medium-lift Soyuz rocket, now operating from Europe's Guiana Space Center in French Guiana, on South America's northeast coast.

Whether a second Galileo

launch will occur this year depends not only on the first satellite's test results but also on the Soyuz rocket's availability. The vehicle is in high demand this year, both for several ESA missions in addition to Galileo and for commercial launches.

The biggest contract competition under way at OHB is for the German Defense Ministry's second-generation SAR-Lupe radar

reconnaissance satellite network.

In a breakthrough contract in 2001 for what was then a much smaller company, OHB built the first five-satellite SAR-Lupe constellation, which was launched into polar low Earth orbit between 2006 and 2008. The constellation is scheduled to operate through 2017.

Fuchs said his best guess is that the second-generation SAR-Lupe

contract will be awarded in the coming weeks, and almost certainly before July. As was the case in 2001, OHB will be competing against Astrium Satellites' German division.

OHB's Italian subsidiary, CGS SpA, is under contract to the Italian Space Agency to build a high-resolution optical observation satellite, called Opsis. Given the Italian budget difficulties, it is

unclear whether the government will proceed to full Opsis development anytime soon.

But Fuchs said CGS has completed the intermediate design review for Opsis, and that the program is making "good progress."

Fuchs said the company's rapid expansion, which has included new facilities and aggressive hiring, will plateau late this year.



May 20, 2013

Thuraya Planning To Wade into Maritime Broadband Market in 2014

PETER B. de SELDING, PARIS

Mobile satellite services provider Thuraya Telecommunications reported an 11.5 percent increase in revenue for the first three months of 2013 compared with a year ago and will provide a maritime broadband product by early 2014 to compete

directly with rival Inmarsat's Fleet Broadband, Thuraya Chief Executive Samer Halawi said May 16.

The product, which does not yet have a name, has faced multiple delays in part because of issues with Thuraya's previous equipment manufacturer and has left the Dubai, United Arab Emirates-based

company largely outside the high-growth maritime market.

In an interview, Halawi said that will change in early 2014 as Thuraya addresses what it said is the market's "desperate" need for an L-band alternative to London-based Inmarsat's product. Thuraya has recently begun selling its land-mobile terminals for

maritime applications, but "it is not ideal" for certain maritime customers that need marine-ruggedized products, he said.

With not much of a stake in the game, Thuraya up to now has mainly stayed out of the argument between Inmarsat and providers of Ku-band VSAT, or very small aperture terminal, deck-mounted

terminals. The VSATs provided higher throughput, generally at much lower cost than Inmarsat- or Thuraya-provided L-band.

But Halawi said Thuraya is encountering many prospective maritime customers who are leery of adopting a Ku-band VSAT solution because of concerns about signal dilution in heavy rain.

It is not a new debate. The Ku-band VSAT providers — and Inmarsat as well, which has purchased a maritime VSAT provider and is planning its own Ka-band service — say today's technologies permit higher-frequency transmissions to penetrate rain so that the degradation of service is not consequential.

Halawi said Thuraya will nonetheless be sticking with L-band for now, pending a larger review of the company's strategy in the next year or so. Halawi has spoken of possible strategic partnerships with VSAT providers.

For now, Thuraya is focused on building its own business through the company's three large geostationary-orbiting satellites. Halawi said Thuraya is investing \$40 million between 2012 and 2016 on network upgrades to provide higher throughput and better coverage.

The company's partnership with Softbank Mobile of Japan, which took effect in February, has already resulted in the sale of some 1,300 Thuraya terminals to Softbank customers in Japan.

Thuraya's SatSleeve product, which transforms an iPhone 3 or iPhone 4 into a dual-mode satellite-terrestrial terminal, will roll out its iPhone 5 product in June, and a data model to permit WiFi links by September, Halawi said.

Halawi said Thuraya will remain a spectator, for now, in the machine-to-machine business, which has become a focus of competitor Inmarsat and is the core market for satellite constellation owner Orbcomm of the United States.

"Where is the revenue for this?" Halawi asked. "Everybody talks about how this market is growing, but for now the revenue [per subscriber] is peanuts. It's also a drag on your network because you must keep the network awake. We are looking at it, though."

Thuraya is a private joint stock company in the United Arab Emirates and does not disclose its revenue, unlike its competitors, which are publicly traded companies. Thuraya's nondisclosure policy has obliged company officials in the past to fight off rumors about the service's performance and financial results.

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NEWS BRIEFS

NEWS BRIEFS FROM PAGE 3

Eutelsat 3D Telecom Satellite Launched on Proton Rocket

An International Launch Services (ILS) Proton Breeze-M rocket on May 15 successfully placed the Eutelsat 3D Ku- and Ka-band telecommunications satellite into transfer orbit in the third of a planned six monthly commercial ILS launches scheduled through August.

Eutelsat announced immediately after the launch that it had signed another contract with Reston, Va.-based ILS, for an unnamed satellite to be orbited between 2014 and 2016. Eutelsat has six satellites under construction and scheduled for launch by late 2015.

Paris-based Eutelsat and satellite builder Thales Alenia Space of France and Italy confirmed that the 5,400-kilogram Eutelsat 3D, carrying 53 Ku-band and three Ka-band transponders, had begun solar array deployment in orbit and had been communicating with ground teams.

Eutelsat 3D will have a Ku-band beam trained on sub-Saharan Africa, another covering Europe, the Middle East and parts of Central and South Asia, and a Ka-band beam covering most of Europe, Russia and the Middle East.

Operating from Russia's Baikonur Cosmodrome in Kazakhstan, the Russian Proton Breeze-M vehicle separated the Eutelsat 3D after a mission lasting nine hours and 13 minutes and including five ignition sequences of the Breeze-M upper stage.

ILS President Philip R. Slack, who watched the launch from Eutelsat's headquarters here, said the company is on track to launch six commercial satellites by August as it returns to flight following a Proton launch anomaly in December.

The Eutelsat launch was the third of these six missions, following launches of the Satmex 8 satellite in March and the Telesat Anik G1 in April. Next up is the SES-6 satellite, owned by SES of Luxembourg, which is scheduled for June, Slack said. SES-6 has already arrived at the Baikonur spaceport.

Speaking with journalists after the

liftoff, Slack said it will take several more weeks before ILS and its owner, Khrunichev State Research and Production Space Center of Moscow, which is owned by the Russian government and is Proton's principal manufacturer, to determine the Proton launch manifest after August.

The Russian government is a regular customer for Proton rockets, and the Proton schedule between September and December will depend in part on what satellites are ready, Slack said.

Eutelsat 3D will operate at 3 degrees east in geostationary orbit for about a year. Following the successful launch of the Eutelsat 3B satellite in 2014, Eutelsat 3D will be moved to 7 degrees east, Eutelsat Chief Executive Michel de Rosen said during a presentation to the audience gathered to watch the launch here.

The audience included representatives from the governments of Bolivia and Peru, a signal that Eutelsat, like several other North American and European satellite fleet operators, is eyeing Latin America for part of the company's future growth plans. Eutelsat has won rights to an orbital slot over Brazil but has not announced its plans there.

Loral Compensates MDA For IS-19 Payment Loss

Loral Space and Communications has made a \$6.5 million cash payment to MDA of Canada to compensate MDA for the loss of future orbital-incentive payments from a satellite built by Space Systems/Loral, which Loral sold to MDA in November, Loral said.

The Intelsat IS-19 satellite, launched in June 2012, suffered a partial loss of capacity when one of its solar arrays did not fully deploy. As is common in satellite contracts, Luxembourg- and Washington-based Intelsat had withheld a portion of the payment due Space Systems/Loral as orbital incentives.

Orbital incentives typically amount to 10 percent of a satellite's contract price. They are paid out annually, with interest, by the satellite's owner for the spacecraft's scheduled 15 years of in-orbit service. A manufacturing defect discovered at any

time during this period can reduce future orbital incentive payments.

Intelsat has received an \$85 million insurance claim as a result of the solar array defect.

In a May 9 filing with the U.S. Securities and Exchange Commission, New York-based Loral said the IS-19 contract included \$18 million in orbital incentives that would have accrued to MDA in the coming years.

The solar array deployment failure has reduced those expected payments by \$6.5 million, resulting in the cash payment from Loral to MDA, Loral said. Any further reductions in the IS-19 incentive payments resulting from satellite defects discovered before Nov. 2 will result in corresponding additional Loral payments to MDA, Loral said.

SpaceX To Refly Columbia Plant Growth Experiment

A plant growth experiment lost in the 2003 Space Shuttle Columbia accident is being revamped for reflight to the international space station aboard the next Space Exploration Technologies Corp. (SpaceX) Dragon cargo ship.

The experiment, called BioTube, is intended to test if a strong magnetic field can replace gravity in influencing the direction plant roots grow in space.

"Right after the germination, the roots decide which way to grow. So the entire experiment is really interested in about the first 48 hours of how these roots grow when they are subjected to a magnetic field with no gravity," said Don Platt, president of Melbourne, Fla.-based Micro Aerospace Solutions, which is developing the revamped BioTube.

The experiment is a follow-on to one that flew on STS-107, the last flight of Columbia, which was destroyed during re-entry following a 16-day research mission. All seven astronauts aboard were killed.

"The experiment worked quite well but obviously the payload was lost," said Platt, who was previously employed by experiment developer Bionetics Corp. in Cape Canaveral, Fla.

Platt's company is now preparing the backup unit, which did not fly on Columbia, to be launched on SpaceX's third space station cargo run. NASA's launch schedule shows the mission is slated for liftoff in November.

"They've changed the seeds because of genetic mapping and what they have maps of now, so we've redone the experiment

totally to fly to the international space station," Platt said.

BioTube, which is about the size of a microwave oven, originally flew inside a Spacehab module in the shuttle's cargo bay. It was part of an overall research initiative to understand how gravity sensing systems in plants and small organisms operate.

Eutelsat and RSCC Order Satellite from Astrium

Astrium Satellites will build a Ku-/Ka-band telecommunications satellite for Russia's RSCC and Europe's Eutelsat to be launched in 2015 to reinforce the two operators' broadcast lineup at 36 degrees east longitude, RSCC and Eutelsat announced May 15.

The satellite, Express-AMU1/Eutelsat 36C, will carry up to 70 transponders and will add to the television broadcast capacity currently at the 36 degrees east position provided by Eutelsat 36A.

The Russian Satellite Communications Co. (RSCC), which is Russia's biggest telecommunications satellite fleet operator, will use the satellite to meet increasing demand in the European portion of Russia for satellite television.

Eutelsat will make the same use of the capacity, and in addition will operate a beam over sub-Saharan Africa.

Paris-based Eutelsat said a recent survey it commissioned found that 24 percent of Russia's 53 million households have satellite television equipment installed, with the audience growing by 25 percent, to 12.6 million homes, in the past two years.

Some 10 percent of the satellite-connected homes receive signals from at least two satellite positions, often necessitating a second dish antenna. Eutelsat said the total population of Russian satellite television antennas is 13.8 million.

The number of Russian homes whose antennas are pointed at the Eutelsat/RSCC 36 degrees east slot has increased by 60 percent in the past two years and now totals 10.7 million. During the same period, the number of Russian television channels broadcasting from 36 degrees east has increased by 48 percent, to 370, according to Eutelsat.

"The 36 degrees east orbital slot serves as an excellent example of successful and mutually beneficial Russian-French cooperation," RSCC Director-General Yuri Prokhorov said in a May 15 statement. "We are happy that our partnership with Eutelsat is taking another step forward."

Dream Chaser Lands in Dryden for Flight Tests

Sierra Nevada's Dream Chaser flight vehicle arrived May 15 at NASA's Dryden Flight Research Center in Edwards, Calif., where it will undergo tests of its flight and runway landing systems.

Louisville, Colo.-based Sierra Nevada Space Systems is one of three companies developing astronaut transportation systems under NASA's Commercial Crew Program. Sierra Nevada said in a May 13 press release that it will conduct runway tow, ground resonance and captive flight tests on its lifting-body spacecraft. Sierra Nevada is developing Dream Chaser with \$212.5 million in financial aid from NASA. If

completed successfully, these tests, which are part of a single milestone under the company's Space Act Agreement with NASA, are worth \$15 million to Sierra Nevada.

Meanwhile, Sierra Nevada has also completed a so-called Integrated Systems Safety Analysis Review, NASA said in a May 10 press release. For that milestone, Sierra Nevada provided NASA with hazard reports and safety and reliability plans for the major components of the Dream Chaser system, including the craft's integration with its planned carrier rocket, United Launch Alliance's Atlas 5, and flight and ground systems.



Sierra Nevada Dream Chaser engineering test article arrives at NASA's Dryden Flight Research Center in Edwards, Calif.

◀Space Technology and Innovation▶

NASA Banking on Solar Electric Propulsions's Slow but Steady Push

DAN LEONE, WASHINGTON

The list of technologies NASA says it needs for a crewed mission to Mars notionally envisioned for the 2030s includes large-scale electric propulsion systems that dwarf those used today aboard many satellites.

"The type of solar electric propulsion that is flying now, at the 4 kilowatt or 5 kilowatt level, is very useful for doing things like station keeping," said David Manzella, an engineer with the solar electric propulsion group at NASA's Glenn Research Center near Cleveland. "But it doesn't provide enough thrust to move heavy payloads in short times."

Neither would the first in a series of scaled-up solar electric systems NASA is working on now, which are being paid for by the agency's Space Technology Mission Directorate.

Just as NASA envisions sending astronauts to a relocated asteroid before leaping on to Mars, it has also planned an intermediate step between the small, electric attitude control systems of today and the massive space tugs of tomorrow: a system that generates between 25 kilowatts and 30 kilowatts of power, and that would be first flown in space between 2016 and 2019, Manzella said.

A rig with that much power would mark a manifold increase compared with the electric propulsion systems flying today, but is still far less powerful than the 300 kilowatt to 500 kilowatt



NASA/ANALYTICAL MECHANICS ASSOCIATES ARTISTS' CONCEPT

▲ NASA considers advanced solar electric propulsion technologies essential to future missions into deep space.

systems NASA believes it needs to tug supplies to Mars in advance of a crewed mission.

A potential beneficiary of the mid-range solar electric system NASA is preparing now is the asteroid retrieval mission announced in April. NASA's notional plan is to launch an uncrewed solar-electric spacecraft to capture an asteroid around 10 meters in diameter and tractor it back to the vicinity of the Moon, where astronauts could visit it as soon as 2021 aboard the Orion crew capsule now in development.

Work on technology for that potential mission is under way, with early efforts focused on the

large solar arrays needed to power an all-electric craft that eschews chemical-fired engines in favor of slower but more efficient electric thrusters.

For the solar panels, NASA in September awarded ATK Space Components and Deployable Solar Systems, both of Goleta, Calif., \$6.9 million and \$4.6 million in funding, respectively, to work on collapsible photovoltaic arrays big enough to power a spacecraft fitted with a cluster of electric thrusters about twice as powerful as those flying today.

NASA wants thrusters "in the 10 kilowatt to 15 kilowatt power range as the propulsion to go

with those solar array systems," Manzella said.

To meet that power requirement, ATK is developing a circular photovoltaic array about 10 meters in diameter, a larger version of what it is making for the Lockheed Martin-built Orion spacecraft. The 10-meter array could generate about 35 kilowatts of spacecraft power, said David Messner, vice president and general manager of solar arrays and deployables for ATK Space Components.

"One of the neat things about a configuration that's round is that from a structural standpoint, it's more efficient than linear, rectangular kind of arrays," Messner said.

Rectangular arrays, such as those used aboard the international space station "have to carry wires all the way back to the spacecraft, so as you get really, really long, it requires more mass because of all the wire you need."

ATK is planning to test one of these circular arrays, which it calls MegaFlex, in a 30-meter-diameter thermal vacuum chamber at NASA's Plum Brook Station near Sandusky, Ohio, in early 2014. Messner expects this round of MegaFlex work, which began in September 2012, to wrap up in March.

Meanwhile, Deployable Solar Systems, the other company working on solar arrays that might find their way onto NASA's asteroid tug later this decade, is sticking with the tried and true rectangular solar panel shape — with a few modifications.

"We don't have any motors, we don't have any complex mechanisms, complex hinges or anything," Brian Spence, founder of Deployable Space Systems, said. Once in space, "the array unrolls like a carpet" using the pent-up force of a spring-loaded boom to unstow itself.

Deployable Space Systems, a 20-employee company founded by former ATK Space Component employees in 2008, is planning to vacuum test its novel Mega Roll-Out Solar Array in "the first quarter of next year," Spence said May 14.

A possible spot for the test is

SEE PROPULSION PAGE 21

As Work Begins on New Spacesuit, Researchers Look Further Ahead

DEBRA WERNER, SAN FRANCISCO

As NASA and Congress discuss potential destinations for future human spaceflight missions, engineers are developing a new generation of spacesuits that offer the type of protection and mobility astronauts would need to live and work in many different environments.

Although the future spacesuit design will be predicated on the precise destination chosen and exploration tasks planned, engineers are striving to develop spacesuits capable of meeting the anticipated requirements of potential missions, such as a journey to Mars. A Mars mission would pose many of the challenges astronauts may face during future exploration missions, including long-duration space travel, extreme weather and dust, said Amy Ross, advanced spacesuit assembly technology lead at NASA's Johnson Space Center in Houston.

In April, NASA awarded a \$4.4 million contract to ILC Dover of Frederica, Del., to design, manufacture and test the

next-generation Z-2 spacesuit. Under an 18-month contract, ILC Dover plans to produce two versions of the suit for NASA Johnson. Both are designed to allow astronauts to perform tasks including walking, kneeling and picking up rock samples, but one features a hard composite shell covering the upper torso and the other features a Hybrid Upper Torso.

The Hybrid Upper Torso uses a metal composite frame covered with a special fabric designed to retain spacesuit pressure. The Hybrid Upper Torso will use replaceable components to achieve a custom fit to enhance comfort and mobility, said Phil Spampinato, ILC Dover director of technology development partnerships. ILC Dover plans to produce the Hybrid Upper Torso frame by melting successive layers of a metal composite, a process known as additive manufacturing.

Both versions of the ILC Dover Z-2 spacesuit are designed to operate at higher pressure than spacesuits currently used by international space station crews working

outside the outpost. In contrast to current space station suits, which are designed to operate at 4.3 pounds per square inch, the Z-2 spacesuit will be designed for pressure of 8.3 pounds per square inch. That increased pressure will enable astronauts to work outside the space station without first spending hours breathing pure oxygen to remove nitrogen from their blood and prevent decompression sickness. Inside the space station, astronauts experience pressure of 14.7 pounds per square inch, the same level present at sea level on Earth.

NASA is scheduled to begin testing the Z-2 suit following its delivery in 2014. It will then be mated with a new portable life-support system being developed at NASA Johnson. With adequate funding and continued progress in the development and testing of the portable life-support system, NASA could begin testing a version of the Z-2 onboard the international space station as early as 2017, Ross said.

As the Z-2 proceeds through development and testing, a team comprising

Draper Laboratory and the Massachusetts Institute of Technology (MIT) is working with NASA to identify technology that could offer continued improvement in spacesuit designs. Cambridge, Mass.-based Draper is using internal research funding to design a spacesuit that employs complex algorithms and control moment gyroscopes built into an external jetpack to help astronauts maintain stability while repairing spacecraft or exploring asteroids. The technology is designed to provide attitude control to offset the various torques and forces produced when astronauts turn wrenches or strike objects with hammers. Without the counterbalancing force of gravity, those simple actions can push astronauts away from their work.

While astronauts currently use tethers and jetpacks to return to their desired location, the new suit is designed to reduce the need for tethers, give astronauts greater range of motion and preserve jetpack fuel. If,

SEE SPACESUIT PAGE 21

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SPACE TECHNOLOGY AND INNOVATION

Satellite Test Device To Simulate Nuclear Effects

MIKE GRUSS, WASHINGTON

The U.S. military's most robust communications satellites, designed to withstand severe space weather and even nuclear detonations, will be battle tested by engineers at Arnold Air Force Base in Tennessee using a newly built device that simulates high-radiation events.

The Military Satellite Communications Atmospheric Scintillation Simulator, or MASS, developed by Welkin Sciences of Colorado Springs, Colo., and the Arnold Engineering Development Complex's Test Technology Branch at a cost of \$2.6 million, is expected to be delivered to the Air Force this summer. Officials have said the simulator provides the most realistic scintillation tests the satellites have faced.

"It's the most you can do beside set off a nuclear bomb in the ionosphere," said Bill Sward, Welkin Sciences' engineering manager.

The goal of the project is to help the Air Force precisely test space systems, such as the Advanced Extremely High Frequency super-secure military communications satellites, to ensure they can withstand disturbances, both natural and man-made.

The U.S. military is heavily dependent on its superior space capabilities, and planners have long feared that a future adversary will try to neutralize that advantage, perhaps by exploding nuclear weapons in space or the upper atmosphere. The electromagnetic pulse from such blasts could disrupt radio frequency communications signals, a phenomenon that scientists call scintillation.

Gen. William Shelton, commander of Air Force Space Command, has made the resiliency of the nation's space assets a top priority in recent years. As a result, scintillation has received more attention from the service.

For example, the Air Force has included about \$7 million for ionospheric research programs in its 2014 budget request. Budget documents call for developing "improved scintillation specification and forecast capability" for space-based communications and navigation systems.

The MASS simulator could test the effects of scintillation on a variety of space programs, program officials said, because of its modular construction, which allows it to easily fit with several satellites, ground systems or terminals. According to contract award documents, the Air Force wants to be able to use the simulator to test the Secure Mobile Anti-jam Reliable Tactical-Terminal, also known as SMART-T.

MASS is one of the first simulators designed to test terminals, which connect to the satellite, not just the modems, program officials said. Previously, scintillation tests regularly meant testing the modem to withstand an attack, but did not include the satellite itself or the uplink and downlink, said Taylor Swanson, an aerospace engineer at Arnold, who has worked closely on the project.

"We kind of break into the signal paths and introduce scintillation," Sward said.

The simulator provides a wide range of models to mimic different scenarios, including multiple events, natural radiation or a nuclear detonation in the ionosphere.

The project's development was funded under the Small Business Innovative Research program, which gives money to small U.S. businesses to work on research and development programs for the federal government.

The market for the product is small, Sward said. But Sward said his company has had an inquiry for a quote from a Defense Department prime contractor that wanted to purchase a simulator to perform its own tests.

F6 FROM PAGE 4

operate as a network but without colliding, runs through January 2014, he said.

"We're going to rescope the effort ... to define the end state of the software and develop and deliver it," Davis said in a May 16 interview.

Davis said the formation-flying software will have future applications in any number of space and unmanned aircraft missions, both for NASA and the Department of Defense. "All I see is opportunity," he said.

Tousley said technologies developed and tested to date for System F6 will feed into other space projects, not only at DARPA but also at the Air Force. Among them are DARPA's Airborne Launch Assist Space Access (ALASA) effort, aimed at demonstrating a low-cost satellite launcher, and the Phoenix satellite-salvaging demonstration, he said.

Boeing, Lockheed Martin and Virgin Galactic are studying ALASA launch concepts under contracts awarded about a year ago, and DARPA likely will downselect to one or two for flight demonstrations that would take place in 2015 or 2016, Tousley said. "We

think that's a critical mission area," he said.

In recent years, DARPA has canceled two efforts to develop a low-cost airborne satellite launcher, Rascal and Falcon.

Phoenix, being led by the Naval Research Laboratory, is intended to demonstrate the feasibility of extending the lives of geostationary-orbiting satellites by replacing fuel or spent components like batteries. The demonstration, targeted for launch in 2016 or 2017, will involve a satellite that has already been moved into a graveyard orbit above the geostationary-orbit arc, which is roughly 36,000 kilometers above the equator.

DARPA is requesting \$40 million each for the ALASA and Phoenix programs next year, according to the agency budget documents.

DARPA's SeeMe effort to design a constellation of low cost imaging satellites able to deliver data to hand-held devices in near-real time is funded through completion of Phase 1 studies, Tousley said. The agency is requesting more than \$10 million for the SeeMe program next year, compared to \$15.5 million in 2013, the budget documents show.

In Switch, Astrium's Hardware Business Outshines Services

PETER B. de SELDING, PARIS

Europe's EADS aerospace company on May 14 said double-digit increases in revenue in its Astrium Satellites and Space Transportation divisions overcame a sharp drop in revenue in the once high-flying Astrium Services business.

Total Astrium revenue for the three months ending March 31 was 1.369 billion euros (\$1.78 billion), up 3 percent from the same period a year ago. Earnings before interest and taxes was 4.8 percent of revenue, down from 4.9 percent a year ago, reflecting the generally lower margins in the hardware businesses compared with the services sector.

Astrium's backlog at March 31 stood at 12.1 billion euros, down from 12.7 billion euros as of Dec. 31.

Astrium Space Transportation, which builds Ariane 5 heavy-lift launch vehicles, European space station hardware and France's strategic missiles, reported a 10 percent increase in revenue, to 609.5 million euros, for the three months ending March 31. The Ariane 5 vehicle notched its 54th consecutive success during the quarter and is scheduled to launch five more times in 2013.

Astrium Satellites reported revenue of 383.3 million euros, up 11.3 percent from a year ago.

Astrium Services, which until recently was Astrium's growth engine, reported revenue of 314.9 million euros, down 15 percent from a year ago.

EADS Chief Financial Officer Harald Wilhelm said in a May 14 conference call with investors that the services business' "presence in certain markets is more difficult."

He did not detail what Astrium Services businesses were feeling the pressure. Among other things, the division provides military X-band communications to the British government and other allied governments through the company's groundbreaking Skynet 5 contract, which runs to 2022, with the British Defence Ministry.

The latest of the Skynet 5 satellites, Skynet 5D, entered service in April. Astrium Services also

owns an X-band payload that was recently launched aboard commercial fleet operator Telesat's Anik G1 satellite.

In addition to selling satellite bandwidth to government and military customers, Astrium Services markets optical and radar Earth observation imagery worldwide through the French Spot and German TerraSAR-X

and TanDEM-X satellites.

Spot 6, financed entirely by Astrium Services, began operations earlier this year, as did the Pleiades 1B high-resolution optical satellite, which joined its twin, Pleiades 1A. The two Pleiades spacecraft were financed by the French government, with French defense forces allotted a portion of Pleiades imagery.

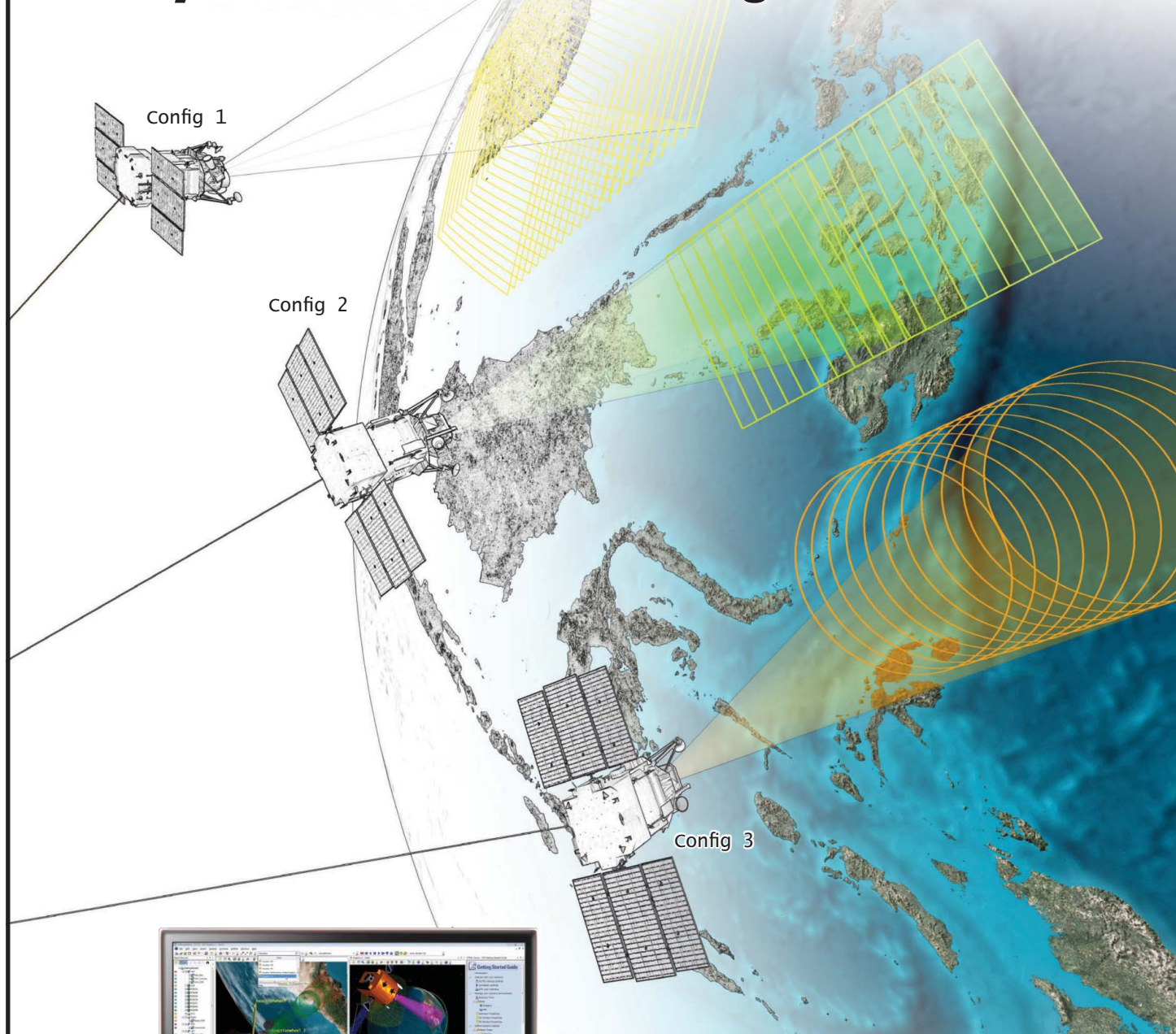
Astrium Services markets the rest of the Pleiades capacity, going head-to-head with DigitalGlobe of the United States in the growing market for high-resolution optical geospatial imagery. The Spot 6 and future Spot 7 optical satellites will preserve Astrium Services' position in the medium-resolution market, which Astrium and the French government have

maintained through the Spot satellite series for more than 25 years.

Astrium Services and the German government are in discussions about how to proceed with a next-generation commercial radar capacity to succeed TerraSAR-X.

Comments: pdeselding@gmail.com

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Commercial Space Advocates Want Bigger Role in Exploration

DAN LEONE, WASHINGTON

Commercial space advocates here said the private sector should have a larger role in NASA's exploration plans, even as a legislative aide warned the agency is in line for another difficult budget year.

"As we look toward the future, commercial space does not stop at low Earth orbit," Mike Gold,

director of Washington operations for Bigelow Aerospace and chairman of the Federal Aviation Administration's Commercial Space Transportation Advisory Committee (COMSTAC), said at that group's annual spring meeting May 15.

"I find it a bit of a false debate ... that somehow it's commercial space versus NASA leading our exploration effort," said Steve Isakowitz,

Virgin Galactic vice president and chief technology officer.

NASA says using spacecraft such as those being developed by Boeing, SpaceX and Sierra Nevada under the Commercial Crew Program, will free up money for deep space exploration.

NASA is spending \$1.1 billion to finance development of three competing craft with the hope

that at least one of will be ready to launch crew to the space station in 2017.

NASA consistently has asked for hundreds of millions of dollars more for the Commercial Crew Program than Congress has been willing to give. For 2014 NASA is \$821 million, a 70 percent increase over 2013.

Meeting that request will be all

but impossible, a House aide told COMSTAC members.

"Say overnight there was 100 percent consensus that we wanted to fund [Commercial Crew] at the president's level. I'm not sure the resources are there," said Thomas Culligan, legislative director for Rep. Frank Wolf (R-Va.), the chairman of the House Appropriations commerce, justice, science subcommittee.

NASA says that it would need to downselect to one aspiring provider if Congress shortchanges Commercial Crew again. That could happen as soon as summer 2014, when NASA plans to award the next round of Commercial Crew funding.

A draft solicitation for that funding is due this summer. The final solicitation is expected in the fall, Ed Mango, Commercial Crew program manager, said May 15.

To win the next round of funding, he said, companies will have to propose at least one crewed mission to the station. The demo mission, Mango said, might even carry a NASA astronaut.

"We're still open to discussions on that," Mango said.

Comments: dleone@spacenews.com

ALPHASAT FROM PAGE 5

of Astrium Satellites, said the company is still integrating an Alphabus/Alphasat offer into commercial bids. While it is not at the core of today's commercial demand, Alphasat is well suited to certain high-power applications, of which mobile communications such as Inmarsat's service is only one, Beranger said.

Inmarsat and Astrium officials here stressed above all the digital signal processor that Astrium provided for Alphasat I-XL.

Pinto said the processor is actually eight integrated signal processors, working in two groups of four, with a combined mass of nearly 250 kilograms. Each of the processors is composed of 17 core computers. The ensemble is capable of performing 2 trillion operations per second.

It is this technology that will give Alphasat IX-L its ability to move power and thus bandwidth around the coverage area of the satellite, which includes all of Africa, the Middle East, most of Europe and Central Asia.

Other commercial satellite operators have said they are seeking flexibility but cannot afford the cost of a digital signal processor. As a result, they opt for bent-pipe satellites that do not feature on-board processing. But with ESA and CNES in the financial loop, Inmarsat concluded that Alphabus/Alphasat was good value for money, Pearce said.

Whether other commercial operators will come to the same conclusion without ESA and CNES remains to be seen.



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May 20, 2013

Orbcomm Ready To Ship 8 Sats for Fall Launch on Upgraded Falcon 9

PETER B. de SELDING, PARIS

Satellite machine-to-machine (M2M) messaging service provider Orbcomm said the launch of the first eight of its second-generation satellites is likely to occur this fall after its launch services provider, Space Exploration Technologies Corp. (SpaceX), conducts the first two flights of the new Falcon 9 rocket.

The launch, which has been delayed repeatedly, will better position Orbcomm in the competition with exactEarth, majority-owned by Canada's Com Dev, to line up customers for a global automatic identification system (AIS) maritime surveillance service for coastal authorities.

In a May 9 conference call with investors, Orbcomm Chief Executive Marc J. Eisenberg said Rochelle Park, N.J.-based Orbcomm generated \$700,000 in AIS revenue in the three months ending March 31, a period during which it signed four new AIS contracts and issued 13 new AIS-related licenses. That is more than double the AIS revenue from a year ago. Eisenberg said he expects AIS revenue to reach \$800,000 for the three months ending June 30.

Orbcomm has two small AIS-dedicated satellites in orbit. All 17 of the second-generation satellites now under construction by Sierra Nevada Corp. of Sparks, Nev., are being fitted with AIS terminals, which receive data on ship identity, heading and destination for forwarding to maritime port authorities.

Eisenberg said the exact date of the



▲ The launch of Orbcomm's second-generation satellites (above) will better position the company to go against competitors with its AIS maritime surveillance service.

Orbcomm launch will depend on the timing and outcome of the inaugural flight of Hawthorne, Calif.-based SpaceX's upgraded Falcon 9 rocket from Vandenberg Air Force Base, Calif. The flight is scheduled to carry Canada's small Cassiope satellite into polar low Earth orbit. A second launch of the new rocket, from Cape Canaveral Air Force Station, Fla. — this one carrying the SES-8 commercial telecommunications satellite into geostationary transfer orbit — is now tentatively set for August.

Eisenberg said that the eight Orbcomm

satellites are ready to be shipped and are waiting only on a firm SpaceX launch date. If July's inaugural launch of the new Falcon 9 occurs on schedule and with no major glitches, he said, the Orbcomm launch could occur between October and December.

In addition to providing a fuller AIS capability, the second-generation Orbcomm satellites will provide faster M2M links and better coverage of northern latitudes because they will orbit at higher inclinations relative to

the equator than the 26-satellite first-generation system.

The remaining nine second-generation Orbcomm satellites currently under construction are scheduled for launch in mid-2014, also on the new Falcon 9 rocket.

Orbcomm said that as of March 31 it had 777,000 billable subscriber units deployed, a net increase of 19,000 from the same period a year ago. Orbcomm revenue for the three-month period was \$16.7 million. That is a 20 percent increase from a year ago but the comparison is complicated by a large back-billing adjustment Orbcomm made with respect to one customer that resulted in a one-time increase in service revenues.

Similarly, a sharp decline in product sales compared with a year ago is largely due to an exceptionally large order in early 2012 from a Japanese customer.

Orbcomm's purchase of several companies in recent months also makes year-to-year comparisons difficult, but Eisenberg said 2013 should see increased revenue for both services and product sales compared to 2012.

One of Orbcomm's recent acquisitions, GlobalTrak, recently won a competition to monitor fuel-transport vehicles in Afghanistan for the U.S. Defense Logistics Agency. Eisenberg said the fact that U.S. troop levels in Afghanistan are coming down should not affect the contract because the same vehicles will be deployed somewhere else, and the need to keep track of their cargo will remain.

Orbcomm Chief Blasts Iridium's 'Confusing and Optimistic' Claims about Caterpillar Business

PETER B. de SELDING, PARIS

Satellite machine-to-machine (M2M) services and hardware provider Orbcomm has come out swinging at competitor Iridium's claims that Iridium has locked up most of heavy-equipment builder Caterpillar's future satellite M2M business, spiriting away a major Orbcomm customer.

In occasionally blistering remarks delivered during a conference call with investors, Orbcomm Chief Executive Marc J. Eisenberg said the Iridium claims were "confusing and optimistic."

McLean, Va.-based Iridium Communications announced May 2 that it had won a "large, multi-year agreement" with Caterpillar that Iridium Chief Executive Matthew J. Desch said "establishes us as their primary provider of satellite M2M services."

Desch said the Caterpillar (CAT) deal is "a watershed" event in Iridium's M2M business.

Eisenberg did not wait for investor questions to attack the issue during Orbcomm's May 9 investor conference call.

"For the immediate future, CAT has tens of thousands of Orbcomm hardware [units] in backlog and tens of thousands more still being manufactured. This represents over two years' worth of future deployments," Eisenberg said. "Over the next two years, we do not anticipate any material change to our CAT business. [W]e are not aware CAT has made any decision to transition away from Orbcomm on the product lines we serve in the near future."

Eisenberg conceded that as a customer forced to make decisions among suppliers that need to launch new satellite constellations — this is the case for both Orbcomm and Iridium — Caterpillar logically would seek "to hedge their bets." But he said he is not aware of any competition for Orbcomm-compatible business that Rochelle Park, N.J.-based Orbcomm has lost or

that Iridium has won.

As to Caterpillar's long-term plans, he said, "I don't think anyone knows. I don't think Iridium knows. I listened to [Iridium's] earnings [call] and their conversation, and I've got to tell you it was confusing and optimistic."

"I mean some of the words they used. I've known CAT for 12-15 years and they don't do things like guaranteed contracts. So when someone says they have a large contract, I don't know what a large contract means. Does it mean a contract with a large customer? I didn't see an 8K [a required stock market advisory], did you? Does it mean [the contract] was done on a poster board? Is that a large contract? Does it mean a large guy? I am not quite sure."

"What is a primary provider? CAT doesn't sign you to be a primary provider, they sign you to have the ability to sell your product, and that's it."

"Watershed agreement? I don't even know what a watershed agreement is. So I think they are overly optimistic and they are confusing the market. I understand the pressure they are under. Their business has been contracting for many quarters now."

Eisenberg said it is possible that Iridium won a Caterpillar contract to provide a high-usage network that was more than Orbcomm could provide but concerned no more than several thousand units. "It's not a particularly big contract," he said. "We were a no-bid on that and I am guessing that is probably one of the wins at our competitor."

The importance of Caterpillar to Orbcomm is clear in the company's May 10 filing to the U.S. Securities and Exchange Commission. For the three months ending March 31, Caterpillar accounted for 25.4 percent of Orbcomm's total revenue, compared with 18.5 percent a year ago.

Orbcomm said 33.6 percent of its accounts receivable as of March 31 were with Caterpillar.



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EARTH SCIENCE and Climate Monitoring

Trans-Atlantic Cooperation Explored for TRUTHS and CLARREO Missions

DEBRA WERNER, SAN FRANCISCO

In spite of widespread agreement among international organizations on the need for more accurate climate change forecasts, two satellite missions designed to provide precise measurements of key climate variables have struggled for years to obtain funding.

In an attempt to revive the stalled missions, researchers leading the United Kingdom's Traceable Radiometry Underpinning Terrestrial and Helio Studies (TRUTHS) mission and the U.S. Climate Absolute Radiance and Refractivity Observatory (CLARREO) are exploring international partnerships and devising strategies to make the missions more affordable.

The team behind the TRUTHS mission, which includes the U.K.'s National Research Laboratory, Imperial College London, Rutherford Appleton Laboratory and Surrey Satellite Technology Ltd. (SSTL), is drafting plans to for a scaled-down version of the mission with funding from the U.K.

Space Agency's Center for Earth Observation Instrumentation.

"If we can get something launched quickly and prove unequivocally it does what we say it does, it helps to turn TRUTHS from a science mission into a potential operational mission," said Nigel Fox, head of Earth observation and climate at the National Physical Laboratory.

The goal of TRUTHS is to measure key climate variables, including the sun's energy, clouds and solar energy reflected by Earth, 10 times more accurately than existing space-based observations. TRUTHS seeks to achieve that high level of accuracy by launching a single spacecraft that includes Earth observation sensors as well as a miniature standards laboratory designed to calibrate instruments to measure accuracy according to the International System of Units.

Half TRUTHS

TRUTHS team members are discussing concepts for a scaled-down version of TRUTHS, known as TRUTHS-Lite. "It is too early to say exactly what the new mission will

entail since we are still at an early stage of concept development," said Mike Cutter, head of SSTL's optical payload group. However, the team is evaluating ways to simplify mission elements to make them more affordable and reliable, Cutter said.

Their goal is to create a TRUTHS-Lite mission that would obtain many of the same benefits of the full-scale mission at a fraction of the cost. For example, on-board sensors could be designed to gather spectral data in the range from visible light to short-wave infrared, instead of also measuring ultraviolet radiation, Fox said. TRUTHS-Lite also could be designed for a mission life of three years instead of five or six years as planned for the original mission, Fox said.

Similarly, NASA scientists are looking for ways to reduce the cost of CLARREO, a mission listed as a top priority in the National Research Council's 2007 Earth science decadal survey. CLARREO passed a NASA mission concept review in November 2010 and appeared to be on track for 2017 launch but was halted in 2011 due to funding constraints.

Like TRUTHS, CLARREO includes on-board calibration equipment and instruments to measure reflected solar energy. In addition, CLARREO features GPS radio occultation receivers to monitor atmospheric pressure, temperature and water vapor as well as infrared spectrometers designed to gather data "across the entire spectrum from the ultraviolet to the far infrared," said Bruce Wielicki, CLARREO science team leader.

To lower CLARREO's price tag, mission planners are studying whether CLARREO instruments could operate onboard the international space station instead of on dedicated satellites as originally proposed. Placing the instruments on the space station would achieve more than 70 percent of the mission's science objectives for approximately 40 percent of the cost, Wielicki said. However, NASA's current budget does not include funding to carry out the plan, he added.

Until money is available, the CLARREO team will continue to refine the scientific objectives of

the mission and test mission components to ensure they will perform as intended after launch. "We remain confident in the feasibility, the critical scientific contributions and the readiness of CLARREO to carry out those contributions once the nation is ready to build it," Wielicki said.

In addition to seeking funding from the U.K. Space Agency, TRUTHS mission planners are eager to establish bilateral or multilateral partnerships. "We are open to working with anyone because it is imperative that this mission happens," Fox said. CLARREO and TRUTHS mission teams already share all science and engineering studies, Wielicki said.

With their wide range of complementary observations, the CLARREO and TRUTHS missions could improve the calibration of 30 to 40 other sensors operating in low Earth and geosynchronous orbit to monitor weather, survey land resources and conduct research, Wielicki said. That improved accuracy is needed to determine the real effect of global climate change, Fox said.



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David McGlade, Chairman & CEO, Intelsat
Michel de Rosen, CEO, Eutelsat
Evert Dudok, CEO, Astrium Services
Daniel Goldberg, President & CEO, Telesat
Rupert Pearce, CEO, Inmarsat
Matthew Desch, CEO, Iridium
Samer Halawi, CEO, Thuraya
Khalid Ahmed Balkheyour, President & CEO, Arabsat
Carlos Espinos, CEO, Hispasat
Lincoln Oliveira, General Director, Star One
William Wade, CEO, AsiaSat
Morten Tengs, CEO (from summer 2013), Telenor Broadcasting
Paul Brown-Kenyon, CEO, Measat

Dmitry Sevastyanov, Director General, Gazprom Space Systems
Thomas K. Choi, CEO, Asia Broadcast Satellite
Rashad Nabiyeu, CEO, Azercosmos
Ali Ahmed Al-Kuwari, CEO, Es'hailSat
Adrian Ballintine, CEO, NewSat
Pradman Kaul, President, Hughes Network Systems
Mark Dankberg, CEO, ViaSat
Pierre-Jean Beylier, CEO, SpeedCast

SATELLITE MANUFACTURERS & LAUNCH SERVICE PROVIDERS

Eric Béranger, CEO, Astrium Satellites
Jean-Loïc Galle, President & CEO, Thales Alenia Space
John Celli, President, SSL
Linda Reiners, President, Commercial Ventures, Lockheed Martin Space Systems Company

Stephen T. O'Neill, President, Boeing Satellite Systems International

David Thompson, CEO, Orbital Sciences
Stéphane Israël, Chairman & CEO, Arianespace
Phil Slack, President, ILS
Kjell Karlsen, President, Sea Launch
Gwynne Shotwell, President, SpaceX
Gao Ruofei, Executive Vice President, CGWIC

FINANCIERS & INSURERS

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David Butorac, CEO, OSN
Phil Goswitz, SVP, Space & Communications / Technology Development, DIRECTV
Tim Joyce, VP of Broadcast Operations, Fox International Channels (Europe)
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David Belton, General Manager, MDA Geospatial Services
Bernhard Brenner, Executive Director, Astrium GEO-Information Services
Phil Cottle, Managing Director, ForestRe
Massimo Di Lazzaro, Executive Senior VP, Observation, Navigation and Science, Thales Alenia Space
Gary Gale, Director, Global Community Programs, HERE, Nokia
Robert Gouridine, Sr. Director, Regional Marketing, DigitalGlobe
Tom Ingersoll, CEO, Skybox Imaging
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Ed Irvin, Vice President International, Lockheed Martin Space Systems
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Michael Menking, Senior Vice President of Earth Observation, Navigation & Science, Astrium Satellites
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SPACENEWS



COMMENTARY

< EDITORIAL >

Stay on Top of the James Webb Space Telescope

NASA Chief Must Always Be Ready with Answers on Observatory's Status

During an April 23 hearing that focused primarily on NASA's strategic human spaceflight activities, House Science, Space and Technology Committee Chairman Lamar Smith (R-Texas) asked NASA Administrator Charles Bolden to comment on reports of instrument delivery delays on the agency's flagship astronomy observatory, the James Webb Space Telescope.

Mr. Bolden's response: "That's news to me."

That was the wrong answer. Wrong not because it isn't true — it's perfectly plausible that Mr. Bolden had not been informed about any new issues with the program, perhaps because there are none, or at least none that might threaten its schedule. Indeed, Mr. Bolden's response was one that is commonly used to indicate some measure of surprise at the question or statement that prompted it.

But therein lies the problem. Clearly the head of an agency with a \$17 billion annual budget cannot be expected to keep close track of all of its programs, even flight projects costing hundreds of millions of dollars. But this is the James Webb Space Telescope, by far NASA's biggest science development program, which has a history of massive cost overruns, lengthy delays and a price tag that at last check was a whopping \$8.8 billion.

Congress, exasperated with NASA's seeming inability to contain the cost growth, threatened to kill the project a couple of years back, despite industry warnings that thousands of jobs could be lost as a result. Lawmakers ultimately were persuaded to continue funding the program due to its scientific potential — Webb is the successor to NASA's most successful science program ever, the Hubble Space Telescope — and by NASA promises to get things under control. To that end, NASA pulled the program out of its astronomy budget account and placed it under the management of a special program office at NASA headquarters, reporting directly to the agency's associate administrator — No. 3 in the agency's management hierarchy — and the associate administrator for the Science Mission Directorate.

In order to accommodate the observatory's inflated cost within a budget expected to remain flat — at best — for the foreseeable future, NASA has put new large science missions on hold, including flagship-class planetary missions. Making matters worse is sequestration, which began taking a bite out of agency budgets in March. Even at the small end of the scale, NASA managers are feeling the squeeze: Paul Hertz, director of NASA's Astrophysics Division, said recently that funding is so scarce these days that competitions for new explorer-class small missions are on hold so the agency can get started on a pair of recently selected projects in a similar size category.

Mr. Smith's question about the status of the James Webb Space Telescope was prompted in part by the U.S. Government Accountability Office, which flagged the observatory in an April 17 report that otherwise credited NASA with better management of its programs. The report specifically said two Webb instruments were 11 months behind schedule.

The instrument delays first came to light last year. A James Webb program manager said in January, however, that the program had sufficient margin in its latest budget and schedule to accommodate the instrument delays with no impact to either.

That's reassuring. What's less than reassuring is that the NASA administrator, who should be maintaining a laser-like focus on the James Webb Space Telescope, apparently was not prepared to give Mr. Smith a detailed account of the status of the development effort.

During a hearing of Senate appropriators the next day, Mr. Bolden seemed much better prepared, saying the program remains on schedule for a 2018 launch despite the instrument delays. Hopefully, he will make a point of always being ready to answer questions regarding the status of the crown jewel of NASA's science mission portfolio. It is likely that he will continue to get plenty of opportunities to do so.

SPACE SHOTS

"After extensive review of all options with the DoD's senior military and civilian leadership on how we address this budget crisis, today I am announcing that I have decided to direct furloughs of up to 11 days for most of the department's civilian personnel. I have made this decision very reluctantly, because I know that the furloughs will disrupt lives and impact DoD operations. I recognize the significant hardship this places on you and your families."

Chuck Hagel

U.S. Secretary of Defense

In a May 14 statement announcing that sequestration-driven furloughs for civilian Pentagon employees will begin July 8 and continue at a rate of one day per employee each week.

"They're going to try to do what?"

Michael Huerta

Administrator, U.S. Federal Aviation Administration.

Speaking May 15 at a meeting of the Commercial Space Transportation Advisory Committee, recounting his reaction when first told about SpaceX's experimental vertical-takeoff, vertical-landing vehicle, Grasshopper

■ Readers are encouraged to express their views in 400-word letters to the editor. Letters may be edited. Please include name, address and telephone number. Unsigned letters will not be published, but names will be withheld upon request. Send letters to 6883 Commercial Dr., Springfield, VA 22159, or to cfranze@spacenews.com. Letters to the editor, opinion and editorial columns may be published or distributed in print, electronic or other forms.

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NASA's Asteroid Absurdity

< ROBERT ZUBRIN >

NASA recently announced that it has embraced the idea of an asteroid retrieval mission as the central goal of its human spaceflight program for the next decade or two. According to the agency's leadership, this mission will accomplish a number of important objectives, including delivering a science bonanza, demonstrating a technology useful for planetary defense, creating a large cache of materials in space that can provide in situ resources to support space exploration activities and achieving the president's goal of flying a mission to a near-Earth asteroid as a way of breaking out of geocentric space and demonstrating human deep-space capabilities necessary for subsequent missions to Mars.

Since this initiative will cost many billions of dollars and, by diverting the entire multibillion-dollar human spaceflight program for decades, impose an opportunity cost amounting to many tens of billions of dollars, it is imperative that these claims be examined critically to see if any of them are true.

Let us therefore consider each of them in order.

There is no doubt that the "asteroid" mission, which involves using an electric propulsion spacecraft with a power supply half that of the international space station to push a 3.5-meter-radius object (i.e., a rock, not an asteroid) to a lunar-like orbit, and then visiting it with astronauts flying sorties in the Orion capsule sometime in the third decade of the 21st century, would eventually return some science. However, vastly more science could be achieved, much sooner, at much lower cost and risk, simply by sending a flotilla of small robotic spacecraft to collect kilogram-sized samples from multiple real asteroids and return them all the way to Earth.

While the electric propulsion system proposed for the so-called asteroid mission can be used over a period of several years of

continuous thrusting to alter the trajectory of 3.5-meter rocks, objects representing planetary threats have masses thousands to millions of times greater, and it would not even be practical to despin them to allow continuous thrusting to begin, let alone deliver to them sufficient propellant or power to change their trajectories. There are tens of thousands of asteroids with radii over 100 meters, each with a mass of over 15 million tons. Assuming that such an object is in an Earth-like orbit, it would require a velocity change of about 1 meter per second to move the periastron of its orbit by a distance equal to the diameter of Earth, and thus have a chance at turning a direct hit into a near-miss. Using electric propulsion, about 500 tons of propellant would be required, and the 40-kilowatt system employed by

being neglected.

The 3.5-meter rock moved to near-lunar orbit in the asteroid mission would have a mass of about 500 tons, which is about 20 times the mass of the system that would need to be launched to low Earth orbit to move it. This might appear to be a good trade, but the rock would likely be only about 5 percent water by weight, so in terms of potentially useful mass delivered to space it would only be a match. However, hydrogen and oxygen launched to low Earth orbit are already in useful form as pure cryogenic propellants, whereas the water in the rock would have to be extracted by processing 3 meters depth of rock, then collected, electrolyzed and cryogenically liquefied, all of which would require a system of considerable power and complexity. Furthermore, in its proposed

The asteroid retrieval mission is not a competent way to advance science, planetary defense, in situ resource utilization or human interplanetary flight. It thus represents an enormous waste of time and money that could prevent NASA's human spaceflight program from achieving anything worthwhile for decades.

the asteroid mission would need to thrust continuously for 250 years to deliver the necessary push. A much more practical approach would be to send a missile armed with a conventional or nuclear warhead (depending upon the size of the object) to give the asteroid a sudden solid shove by blasting a small portion of its mass off its side. Unfortunately, in order to preserve a false rationale for the asteroid mission's electric propulsion system, such more potent approaches to planetary protection are

near-lunar retrograde orbit, the propellant produced from the rock would be in the wrong place to support useful space exploration activity. In fact, the delta-V needed to leave low Earth orbit to reach the rock propellant depot would be about the same as the delta-V needed to leave low Earth orbit and fly directly to Mars. Therefore, even if the rock propellant depot were there today, ready to provide propellant for free to any Mars-bound mission willing to stop by to refuel, it

would not make any sense to go there.

In situ resource utilization is a key technology to space exploration, but the resources to be used need to be located at the destination of interest, not somewhere else. Martian missions need to use resources located on Mars. Lunar missions need to use resources located on the Moon. A rock in a retrograde lunar orbit is of no resource utilization interest to anyone.

As to the claim that the asteroid retrieval mission achieves the goal set by President Barack Obama in 2010 of breaking out of geocentric space, that is simply untrue. In point of fact, aside from potentially providing a fat contract to an excessively influential electric propulsion company (see my op-ed "The VASIMR Hoax," *SpaceNews*, July 13, 2011), the entire purpose of the initiative is to find a way to shirk the challenge of human interplanetary flight.

The asteroid retrieval mission is not a competent way to advance science, planetary defense, in situ resource utilization or human interplanetary flight. It thus represents an enormous waste of time and money that could prevent NASA's human spaceflight program from achieving anything worthwhile for decades. Congress must not accept this. Hearings need to be held, with the NASA administrator required to defend his plan in the presence of technically qualified critics. If the plan is found to be irrational, then lawmakers need to insist that it be replaced with a space agency strategy that actually makes sense.

The American people want and deserve a human spaceflight program that really explores new worlds. It is past time that NASA stepped up to the plate and accepted that challenge.

Robert Zubrin is president of Pioneer Astronautics and the Mars Society and author of "The Case for Mars." His latest work, "Mars Direct: Space Exploration, the Red Planet, and the Human Future," was recently published by Penguin.

The Prisoner's Dilemma in Space

< DAVID FINKLEMAN >

The European Space Agency's (ESA) Sixth European Conference on Space Debris, a quadrennial event that recently concluded in Darmstadt, Germany, is a bright star of collaboration to sustain productive use of space.

In 1950, Merrill Flood and Melvin Drescher at Rand Corp. formalized the "Prisoner's Dilemma," which explains why individuals would not cooperate even when it is in their best interests to work together. Since then the classic differential game has been expanded to include social norms and metanorms, many players and diverse rules of engagement, such as whether players might have some knowledge of how the others respond. The fundamental two-player, non-zero-sum game almost always evolves to the worst outcome for all. However, real or societal penalties for defection and understanding that others are willing to cooperate change the outcome.

The ESA meeting exposed diligent accomplishment in the world's space community. Virtually all stakeholders contributed, including the United States, Russia, China, Japan, France, Germany, Italy, Poland, the Czech Republic, the United Kingdom, Spain, South Korea and others in every hemisphere from Scandinavia to Argentina, Europe and Asia. All presented their operational concepts and techniques for perceiving dangerous close approaches among satellites, avoiding collisions and mitigating consequences. All emphasized the need for essential orbit and satellite architecture data and information. The consequences of the current data deficit were described and quantified.

The nature of fragmentation and collisional damage and debris production is much better understood than ever but still evolving. Although estimates of the evolution of the near-Earth debris population do not uniformly predict cascading catastrophe,

it is unanimous that the rate of increase of debris must be diminished and that action is necessary to mitigate the debris risk to active and productive satellites.

No one should doubt the merits of risk reduction through removal of very large, dead rocket bodies and satellites.

There are many innovative and feasible approaches. Industry and governments should invest in developing hardware and mission architectures. The ESA Clean Space Initiative stands out. Although it was not stated specifically, the French space agency, CNES, and its companion organizations appear to have mature concepts and analysis supporting removing Envisat, which became uncontrollable last year.

The task is much more than grabbing and pushing or pulling. Forces must be applied in the right place and in the right direction, and the descent must not jeopardize other satellites or human activity on the Earth.

Envisat is an excellent subject since its mass properties and dynamics are known, its orbit is well characterized, and there are no salvage rights or serious civil legal complications.

The conference exposed sincere, world-wide concern and capability. It introduced into the adversarial commercial and political environment the factors that have been demonstrated to foster collaboration in decades of Prisoner's Dilemma research.

The numerous civil, commercial and governmental stakeholders should join the initiative to remove Envisat and to share data and information that the conference proved essential to preserving and enhancing the productive and fragile near-Earth space environment.

David Finkleman is senior scientist in the Center for Space Standards and Innovation at Analytical Graphics Inc. in Colorado Springs, Colo.

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PROPULSION FROM PAGE 9

Boeing Defense, Space & Security's thermal vacuum chamber in El Segundo, Calif., Spence said.

Meanwhile, with ATK and Deployable Space Systems working on the arrays that will generate power, others are working on the thrusters that will spend that power.

"We have 12-kilowatt systems in development that could be used in much higher power-level systems," said Julie Van Kleeck, vice president of space programs at Sacramento, Calif.-based Aerojet. The company tested one such thruster at Glenn last year, Van Kleeck said.

A 12-kilowatt engine more than doubles the power of the 4.5-kilowatt, xenon-fueled BPT-4000 Aerojet provided for the Air Force's Advanced Extremely High Frequency communications satellites.

Aerojet built the thrusters for the Air Force satellite by licensing technology from a Natick, Mass., company called Busek Space Propulsion and Systems. In April, Busek won \$5.1 million from NASA's Small Business Innovation Research program to work on bigger solar electric thrusters in the 10 kilowatt to 20 kilowatt range.

A Little Thrust Can Go a Long Way

Although NASA insists on pushing the state of the art for the asteroid retrieval mission and later Mars missions, even the comparatively small and weak electric propulsion systems flying today are powerful enough to be useful. The Air Force and Lockheed Martin Space Systems proved that in 2010, when the service's Advanced Extremely High Frequency satellite lost its main onboard engine and had to rely on Aerojet-built electric thrusters to boost from the transfer orbit where its rocket left it up to geostationary orbit. The trip took nine months.

SPACESUIT FROM PAGE 9

for example, astronauts planned to spend several hours exploring an asteroid, they probably would not want to be tethered to a spacecraft, said Bobby Cohan, Draper's Mission Design Group leader.

Draper and MIT plan to test a prototype of the new extra-vehicular activity suit this summer in NASA Johnson's Virtual Reality Laboratory.

In addition to the new extra-vehicular activity suit, Draper is looking for ways to improve the health and performance of astronauts working inside their spacecraft. In September 2012, Draper received \$500,000 from NASA's Innovative Advanced Concepts program for the second phase of a study of technology that could be integrated in an astronaut's clothing to improve his or her ability to adapt quickly to a weightless environment without suffering from common side effects such as motion sickness

The electric thrusters provided by Aerojet for the Air Force satellite — which are among the most powerful being flown today — produce only about 250 millinewtons of thrust. NASA's Dawn spacecraft, which launched in 2007 to explore two of the largest asteroids in the solar system, gets a whopping 90 millinewtons or so from its xenon-fueled ion engine.

For comparison, a commercially available 8-gram, solid-fuel motor for a model rocket can produce just over 10 newtons of thrust at its peak, making it about 1,000 times more powerful than Dawn's engine — for the fraction of a second the toy motor is capable of firing.

Dawn's engine, like other electric thrusters, can stay lit for much longer than that. And they need to. The tiny amount of thrust such engines produce means spacecraft that use them must perform long burns in order to get anywhere.

Despite that handicap, electric propulsion systems offer a large reduction in mass at the launch pad, which has obvious advantages.

Boeing Space and Intelligence Systems, for example, is now planning to do on purpose what the Air Force and Lockheed only did by accident: transfer communications satellites to geostationary orbit with no chemical propulsion at all. In 2012, the Seal Beach, Calif., company sold four of its all-electric 702SP satellites in a joint order from Asia Broadcast Satellite of Hong Kong and Satmex of Mexico.

These satellites are scheduled to launch in pairs aboard Space Exploration Technologies Corp. Falcon 9 rockets in 2014 and 2015. Like electric thrusters on other Boeing satellite models, those on the 702SP are powered by xenon propellant, of which each satellite requires only about 350 kilograms — substantially less than the 2 metric tons of fuel needed aboard satellites with chemical-fired thrusters, Boeing estimates.

and disorientation.

The two-year project, called Variable Vector Countermeasure Suit, seeks to create small sensors and actuators that could be incorporated in an astronaut's clothing to simulate gravitational resistance. Draper plans to house inertial measurement units and control moment gyroscopes in modules slightly larger than a deck of cards that could be placed on an astronaut's arms and legs. The components in each module would monitor velocity and orientation with respect to whatever direction an astronaut specifies and to produce counteracting forces.

By simulating the effects of gravity, the Variable Vector Countermeasure Suit could help astronauts adapt to new gravity environments and prevent the type of muscle and bone loss that often occurs during prolonged periods of weightlessness, said Kevin Duda, Draper's principal investigator on the Variable Vector Countermeasure Suit.

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PROFILE

Michael Gazarik

**ASSOCIATE ADMINISTRATOR,
NASA SPACE TECHNOLOGY MISSION DIRECTORATE**

Creating the Future

Abraham Lincoln wasn't talking about space exploration when he said, "The best way to predict your future is to create it," but it's an idea that Michael Gazarik keeps foremost in his mind as he goes about his job overseeing NASA's space technology programs.

An electrical engineer by training, Gazarik joined NASA after more than 15 years in the private sector developing software for the telecommunications industry and control systems for submarines, among other projects.

"A common thread in my career has been a focus on developing systems, software, hardware or both, to solve difficult problems," he said.

Before moving to NASA headquarters, Gazarik was deputy director for programs in the engineering directorate at NASA's Langley Research Center in Hampton, Va.

He spoke with *SpaceNews* correspondent Irene Klotz about why NASA wants to beef up investments in technology development and what the agency is looking to accomplish.

NASA's 2014 budget request includes a sizable hike in spending for space technology projects. In light of the intense competition for dollars, why is this increase warranted?

In a difficult fiscal environment, the Congress has chosen to invest \$642 million in space technology in 2013. I believe this decision is a result of an understanding of the critical role space technology plays in everything we do. Federal investments in these areas also create high-tech jobs and build our nation's economic and national security.

NASA's proposed \$742 million budget for space technology for fiscal year 2014 is largely derived by what is required to maintain the schedule of a number of our critical activities. Many of the technology development efforts we started in fiscal 2012 and 2013 hit their yearly budget peaks in 2014. As such, this 2014 rise was anticipated.

A small portion of the increase targets a solar electric propulsion (SEP) technology demonstration mission led by the NASA Glenn Research Center. SEP technology has been identified as a critical investment area in numerous technology roadmaps, and it is broadly applicable to NASA's future robotic and human exploration mission goals — including the asteroid return mission concept. It is also an investment area of interest to future U.S. Air Force and commercial space missions. This budget request reflects a recognition that we need to continue to invest in new technologies, new capabilities for the future.

One of NASA's most successful space technology development programs was ion propulsion, which was used in the Deep Space 1 flight demo and later incorporated into the Dawn probe. How can you make sure other technologies developed by NASA find their way into operational missions?

At NASA, we develop technology with a purpose. A prime criteria we have for our technology demonstration missions — the higher technology-readiness-level missions — is that they have infusion partners, meaning organizations that plan to use the technology in future operational missions. We focus on the perceived risks of the technology and ensure the dem-

onstration addresses those risks. Mission infusion is what we're all about. The Deep Space 1 flight demonstration is an excellent example of this approach.

Today, we are incubating several technologies with a similarly high mission-infusion potential. One example is deep-space optical communications, or "laser comm." Once demonstrated, this technology will be infused into future robotic and human missions. It will take deep-space communications from the speed of a dial-up modem to that of high-speed cable Internet.

Other examples include large-scale composite cryotanks and cryogenic propellant storage and transfer technologies with the potential to reduce the mass and cost of future in-space transportation systems and launch vehicles, as well as navigation technologies, solar sails and aerodynamic decelerators.

What is the role of private industry in NASA's Space Technology Program?

Private industry and academia are critical to NASA's future. We are dependent on industry and academia to push the state-of-the-art and take ideas from concepts to flight. History has shown that it is essential to develop and nurture such a community so that breakthrough solutions materialize.

Approximately half of our space technology budget is allocated each year to partnerships with industry and academia. One example in which we're currently partnering with industry is in green propellants. We're developing a greener propellant for use in orbit, eliminating our current dependency on highly toxic hydrazine. This is not just a safety issue, but a technological solution that drives the cost of many of our missions. Along with the Air Force, we're partnering in this endeavor with Ball Aerospace and Aerojet. We will be demonstrating this new fuel in orbit in 2015.

So where would you like NASA's Space Technology Program to be in the next five to 10 years?

In the next five years, I expect to see a number of our technologies infused into missions. I anticipate the solar electric propulsion system being developed and demonstrated as part of the agency's asteroid retrieval mission. I expect infusion of solar



NASA PHOTO BY GEORGE HOMICH

sail, atomic clock and green propellant technologies into future missions. Just beyond that horizon, I expect to see future Mars missions using our laser communications and inflatable aerodynamic decelerators.

How long till we get warp drive, a transporter and all that other cool "Star Trek" stuff?

The Space Technology Program is not science fiction. However, we are working on long-term, breakthrough technologies. We are very conscious of the need to be thinking about tomorrow and we're trying to make sure NASA has on-ramps for new technology ideas at all levels of technology readiness. NASA's Innovative Advanced Concepts program is specifically designed to look for early stage concepts which in 10 to 100 years will result in transformative technologies for space exploration. While funded at a low level today, some of these ideas show real promise.

The National Research Council recommends an investment of 10 percent, and that's about the percentage we invest in early stage ideas.

What technology would you personally and professionally most like to see developed?

My job is to objectively assess all of the paths to achieving our nation's future missions in space and build the technological foundation to enable these missions. I cannot afford to have favorites.

That said, I think it is clear that our nation's space future would most benefit from breakthroughs in access to space, in-space propulsion and in-space manufacturing and manipulation technologies. Advanced solar electric power is one of the required technologies we're going to need to have to take the next big steps in space exploration, and it has so many applications in the commercial space industry.

What do you envision NASA's role to be in the Obama administration's manufacturing innovation institutes initiative?

NASA will provide technical expertise and funding for the selected teams. This is similar to the approach we took with the National Additive Manufacturing Innovation Institute in Youngstown, Ohio. We also will be providing technical expertise and support during the development of the solicitations by the new institutes.

What are the advantages and challenges of doing technology development in a government organization versus private industry?

I've worked for small private and public companies and large companies and even started my own small company in the late 1990s. I enjoyed many years at MIT's Lincoln Laboratory, developing atmospheric sounding instruments before joining NASA's Langley Research Center in 2003.

I love working for our nation's space agency. At NASA, we're not driven by marketing of a product for short-term profits or near-term goals. Our investments are truly investments in America's long-term future. The technologies we're working on are so transformative that without initial government investment, they might not make it to the floor of a corporate research and development lab. We're taking on challenges that are at the cutting edge. We're looking at relocating an asteroid, redirecting its path. We're talking about sending humans into deep space. We're talking about the next great observatory, the James Webb Space Telescope, that will peer back in time to answer fundamental questions about our species and our home planet. Creating the technologies needed to keep our explorers — robotic and human — alive and well is a terrific challenge, one that I think about every day.

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